ESTIMATION OF EXPOSURE OF PERSONS IN CALIFORNIA TO PESTICIDE PRODUCTS THAT CONTAIN MEVINPHOS

By

Tareq A. Formoli, Associate Pesticide Review Scientist
Tom Thongsinthusak, Staff Toxicologist
Jim Sanborn, Staff Toxicologist

HS-1653, September 28, 1992
First Revision, May 17, 1993
Second Revision, March 7, 1994

California Environmental Protection Agency
Department of Pesticide Regulation
Worker Health and Safety Branch
1020 N Street, Room 200
Sacramento, California 95814

ABSTRACT

Mevinphos is a highly acutely toxic organophosphate insecticide that is used on a variety of crops, mainly vegetables. There were 438 cases of suspected systemic illness associated with exposure to mevinphos or tank mixes containing mevinphos in California during 1982 to 1989. Drift accounted for 61 percent of all the illnesses. Mevinphos residues dissipate rapidly from the foliage of crops following application. Mevinphos is rapidly absorbed, metabolized, and excreted after oral or intravenous administration in animals. Dimethyl phosphate (DMP) is a primary metabolite. A dermal absorption of 16.8 percent was estimated based on a mevinphos dermal absorption study in rats. The Absorbed Daily Dosage (ADD) of mixer/loader/applicators using ground rigs was estimated at 3.8 µg/kg/day. The ADDs for pilots, mixer/loaders and flaggers for aerial application were estimated at 0.5 µg/kg/day, 2.4 µg/kg/day and 0.04 µg/kg/day, respectively. Field workers' exposure estimates ranged from negligible to 11.0 µg/kg/day.

This exposure assessment was prepared to be included in the Department risk characterization document for mevinphos because of a low NOEL observed for cholinergic effects in laboratory animals and in humans.

Department of Pesticide Regulation
Worker Health and Safety Branch

Human Exposure Assessment

Mevinphos

September 28, 1992
First Revision, May 17, 1993
Second Revision, March 7, 1994

PHYSICALICHEMICAL PROPERTIES

Mevinphos, methyl 3-[(dimethoxyphosphinyl)oxyl-2-butenoate is a colorless liquid (molecular formula $C_7H_{13}O_6P$; CAS #7786-34-7). Phosdrin® and Duraphos® are its trade names. The technical material contains at least 60 percent of the alpha (cis) isomer. It is miscible in water and several organic solvents except hexane.

Boiling Point (0.03 mm Hg)	99 - 103 ^{o}C
Vapor Pressure (25 ^{o}C)	0.0029 mm Hg

Based on the vapor pressure cited above the primary physical form of inhalation exposure for handlers of mevinphos will be as a vapor.

U.S. EPA STATUS

In 1988, the US Environmental Protection Agency (U.S. EPA) issued guidance for the reregistration of mevinphos containing pesticide products. Numerous data gaps were identified. The U.S. EPA also expressed its concerns over the risk posed by the use of mevinphos to handlers and field workers. The Agency reserved consideration of a special review of mevinphos at that time until the data became available; however, mevinphos is currently under U.S. EPA's review.

FORMULATIONS

As of February 8, 1993, there were four mevinphos-containing products registered in California. These are all liquid concentrate/emulsifiable concentrate formulations. One product contains 100 percent mevinphos, which is equivalent to 10.3 pounds (lb.) of mevinphos/gallon. The other three products contain mevinphos in the range of 47 to 50 percent by weight, approximately four lb. of active ingredient (a.i.) per gallon of the product.

USAGE

Mevinphos is used as a broad-spectrum insecticide/acaricide on a variety of vegetable, fruit, and field crops. It is used primarily as a short residual foliar insecticide to "clean up" crops just prior to harvest. Mevinphos can be applied by air or ground power equipment. All product labels, except Phosdrin® 4 EC, prohibit the use of handheld application equipment. Mevinphos must be used through a closed mixing/loading system in California (Title 3, CAC).

A total of 333,790 lb. of mevinphos was used in California in 1990, primarily on vegetable crops (PUR, 1992). Approximately one-half of this amount was used on lettuce. Other mevinphos use crops are shown in Table 1.

Table I

Mevinphos Major Use Crops in California in 1990

Crop	Pounds a.i.	Percent
Lettuce	169,588	50.8
Cauliflower	34,378	10.3
Broccoli	29,325	8.8
Celery	18,650	5.6
Alfalfa	13,954	4.2
Grapes	10,491	3.1
Other	57,404	17.2
Total	333,790	100.0

Formoli, WH&S, 1992

The application rates are 0.25 to 1.0 lb. a.i./acre for vegetable crops, 1.0 to 3.25 lb. a.i./acre for fruit, and 0.5 lb. a.i./acre for forage and grain crops. Mevinphos is a restricted use pesticide because of its high acute toxicity to humans. Therefore, it is for retail sale to and use only by certified applicators or persons under their supervision.

LABEL PRECAUTIONS

All mevinphos-containing products are toxicity category 1, carrying the signal word "Danger-Poison". These products are poisonous if ingested, inhaled, or absorbed through the skin. Mevinphos is rapidly absorbed through the skin. Repeated inhalation or skin contact may, without symptoms, progressively increase susceptibility to mevinphos poisoning. The following protective clothing and equipment must be worn during application, repair and cleaning of equipment, and disposal of mevinphos:

1. Protective suit of one or two pieces, made of cloth or chemical resistant material, that covers all parts of the body except head, hands, and feet (worn over normal work clothing).
2. Chemical resistant gloves.
3. Chemical resistant shoes, or shoe coverings, or boots.
4. Goggles or face shield.
5. Hood or wide brimmed hat.
6. NIOSH/MSHA approved respirator.

The following protective clothing and equipment must be worn during mixing/loading:

1. Long-sleeved shirt and long-legged pants.
2. Chemical resistant gloves.
3. Chemical resistant apron.
4. Shoes and socks.
5. Goggles or face shield when the system is under pressure.

If application is made using an enclosed cab or cockpit the following clothing and equipment must be worn as an alternative:

1. Long-sleeved shirt and long-legged pants.
2. Shoes and socks.
3. Chemical resistant gloves must be available in the cab or cockpit, and must be worn during entry to and exit from the application vehicle. For ground application, all other protective clothing and equipment required for use during application must be available in the cab and must be worn when exiting the cab into treated areas.

Human flaggers are strictly prohibited during aerial application unless they are in a totally enclosed vehicle. Reentry to treated citrus, grapes, peaches and nectarines is prohibited for 4 days. The reentry interval for other treated crops is two days (Title 3, CAC).

WORKER ILLNESSES

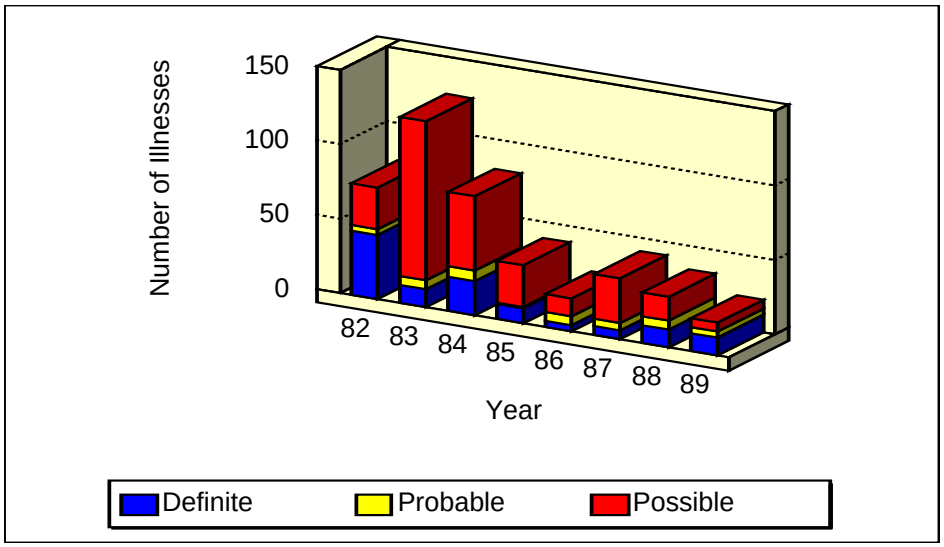
Of the 578 illnesses reported that might be due to exposure to mevinphos alone and mevinphos tank mixed with other cholinesterase inhibiting pesticides, there were 122 definite, 38 probable, 278 possible, and 140 unlikely/unrelated/no symptom cases during 1982 to 1989. The number of cases in definite, probable, and possible categories is shown in Figure 1. A statistical analysis of trend for these cases using Sen's nonparametric test (Gilbert, 1987) indicates a significant (α=0.1) downward trend with an estimated slope of -11.6 (regardless of use trend). The downward trend is marginally but still significant at $\alpha = 0.05$. The Mann-Kendall nonparametric test for trend also supports the conclusion drawn from Sen's test but the later test is preferred when no data are missing (Gilbert, 1987). Even where the estimate of trend is assumed to have a parametric type distribution, the linear regression analysis still indicates a noticeable decline (α= 0.05) in cases, with a regression coefficient of 11.4 and $r = 0.78$.

There were 438 cases of suspected systemic illness associated with exposure to mevinphos in California during 1982 to 1989. Of these cases, 109 identified mevinphos as the primary pesticide and 329 involved exposure to mixtures of mevinphos and other cholinesterase inhibitors. There were 102 cases involving one or more days of hospitalization and 278 cases involving one or more lost workdays. Of the 438 cases, 267 cases resulted from drift exposure, 70 cases were associated with application, 52 cases from field residue, 37 cases from direct exposure, and 12 cases from miscellaneous exposure (O'Malley, 1992).

Drift accounted for 61 percent of all illnesses, mostly as a result of tank mixes. Most of the drift cases were associated with a foul odor due to the organophosphate pesticides tank mixed with mevinphos. Mixer/loader/applicators accounted for 16 percent of all illnesses. Most of the mixer/loader/applicator cases involved direct exposure (O'Malley, 1992).

Figure 1

Mevinphos Yearly Illness Trend In Definite, Probable, and Possible Categories*



- - O'Malley, 1992

DERMAL ABSORPTION

Preliminary data from a mevinphos dermal absorption study in rats indicate rapid absorption in all tested dose levels (Jeffcoat 1993). ^{14}C-mevinphos (vinyl) was applied to the back skin of rats at dose levels of 12.5, 2.5, and 0.4 µg/cm^2. The administered skin area was protected by a non-occluding device equipped with a charcoal-impregnated covering to absorb evaporating mevinphos. The administered skin area was washed just prior to sacrifice or at ten hours after the dose application, whichever occurred first. A group of four rats were sacrificed at six, ten, 24, and 48 hours after the dosing for each dose level. For the low dose level, a group of four animals were also sacrificed at 72 hours after the dosing. Urine, feces, cage wash, expired air,

blood, carcass, administered skin site, skin wash, and protective coverings and traps were analyzed for radioactivity. Radioactivity levels remained fairly unchanged in all media that were collected at six, ten, 24, 48, or 72 hours after the dosing, indicating a saturation point at six hours. The administered skin site contained 33 and 32 percent of the applied radioactivity six and 48 hours after the dosing, respectively. There was no evidence of bioavailability of ^{14}C-mevinphos bound to the administered skin site six hours after the dosing. The sum of radioactivity found in urine, feces, cage wash, expired air, blood, and carcass at 48 hours after the dosing was 15.4 percent of the administered dose. A dermal absorption rate of 16.8 was obtained after a correction for a 92 $\pm$2 percent recovery observed in the study. A dermal absorption rate of 16.8 percent will be used in this document.

METABOLISM

Early metabolism studies have shown that mevinphos is rapidly metabolized and excreted by cows administered mevinphos orally (Casida *et al.,* 1958). The elimination was mostly in urine. DMP was the main metabolite from both alpha and beta isomers of mevinphos, together with small amounts of free carboxylic acid of mevinphos.

Metabolism of mevinphos was also studied in Sprague-Dawley rats (Reddy *et al.,* 1991). Rats were administered a single dose of ^{14}C-vinyl-mevinphos orally (0.15 mg/kg, 1.5 mg/kg), a single dose intravenously (0.15 mg/kg), or a multiple (16 days) dose orally. Most of the radioactivity was eliminated within eight hours of oral or intravenous administration. After 24 hours, 61% to 78% and 14% to 24% of the administered dose was eliminated in the exhaled air ($^{14}CO_2$) and in urine, respectively. Radioactivity in the feces accounted for only 0.5% to 1.4% of the administered dose. The level of radioactivity in all tissues together ranged from 5.4% to 7.5% of the administered dose. Urinary metabolites were identified as O-desmethyl mevinphos acid, O-desmethyl mevinphos, mevinphos, and unknown, comprising approximately 18% of the administered dose. The authors suggested that mevinphos hydrolysis yields acetoacetate which is ultimately converted to $^{14}CO_2$. Hydrolysis would release an equal amount of DMP. The suggested metabolic pathway of mevinphos in rats is shown in Figure 2.

DISLODGEABLE FOLIAR RESIDUE

The Worker Health and Safety Branch conducted a study in 1984 in Salinas, California to monitor dislodgeable foliar residues (DFR) of the alpha isomer of mevinphos on lettuce cauliflower, and Chinese cabbage (Maddy et al., 1985). Mevinphos (Phosdrin® 4E) was used in tank mixes with other pesticides. The rates of application were 0.5 lb. a.i./acre on head lettuce, 0.25 lb. a.i./acre on Chinese cabbage, and 1.0 lb. a.i./acre on cauliflower and leaf lettuce. The pesticides were diluted in 60 to 100 gallons of water per acre and applied using ground rigs with boom sprayers. Leaf samples were collected prior to the application and at several intervals following the applications of mevinphos. Samples were kept on ice and delivered to a mobile laboratory within one hour of collection. Foliar residues were dislodged using a water/dioctyl sodium sulfosuccinate solution and extracted from this aqueous solution into an organic solvent.

Residues were analyzed using a gas-liquid chromatograph. A linear regression from the observed residues was developed for each crop and is shown in Table 2.

Table 2

Dislodgeable Foliar Residues of the Alpha Isomer of Mevinphos on Lettuce, Cauliflower and Chinese Cabbage during 1984 in Salinas

	Predicted Dislodgeable Foliar Residues ($\mu g/cm^2$)				
	Lettuce		Cauliflower		Chinese
	Leaf	Head	Mature	Young	Cabbage
Initial Deposition	0.363	0.239	0.086	0.161	0.666
At 48 hours Post Application	0.036	0.009	0.019	0.029	0.122
At Harvest	**neg.**	**0.009**	**0.009**	**0.012**	**0.122**
PHI (days)	7-10	2-4	3	3	2-3
$t_{1/2}$ (hours)	14	10	22	20	20
r^2	0.69	0.82	0.88	0.76	0.71
n	12	18	27	27	12

PHI - Preharvest Interval
n - number of samples
neg - negligible (<0.0001 $\mu g/cm^2$)

Formoli, WH&S, 1992

The dissipation of mevinphos on lettuce, cauliflower, and celery was monitored by Worker Health and Safety Branch in the summer and fall of 1990 (Spencer *et al.,* 1991). In general, dissipation was rapid. All June applications were made by helicopter and the October applications were made by either helicopter or ground rig. Mevinphos was used at a rate of 0.25 to 0.5 lb. a.i./acre. Samples were taken prior to the application and at several intervals post-application. The samples were extracted within a few hours and stored frozen until delivery to the laboratory. Dislodgeable foliar residues of both isomers (alpha and beta) of mevinphos were summed and reported. The reported data were analyzed using linear least squares regression on the natural log of the total residues versus time of post-application. The results are shown in Table 3.

Table 3

Dislodgeable Foliar Residues of Both Alpha and Beta Isomers of Mevinphos on Lettuce Cauliflower, and Celery during 1.990 Seasons in Monterey County

	Predicted Dislodgeable Foliar Residues (µg/cm²)					
	Lettuce		Cauliflower		Celery	
	June	Oct.	June	Oct.	June	Oct.
Initial Deposition	0.066	0.027	0.304	0.160	0.051	0.074
At 48 hours post application	0.016	0.006	0.155	0.025	0.018	0.009
At harvest	**0.016**	**0.006**	**0.111**	**0.010**	**0.011**	**0.003**
PHI (days)	2-4	2-4	3	3	3-5	3-5
$t_{1/2}$ (hr)	23	22	50	18	31	16
r^2	0.55	0.15	0.54	0.84	0.59	0.75
n	133	133	50	50	36	36

Formoli, WH&S, 1992

No mevinphos DFR studies are available in the Department of Pesticide Regulations (DPR) files on grapes or other fruit crops. Use of mevinphos on grapes contributed 3.1 percent to the total use reported for 1990. The use on other fruit crops is very limited. The DFR on grapes and fruit trees were assumed to be equivalent to those of vegetable crops. The assumed DFR value (geometric mean) at the expiration of reentry interval was adjusted for maximum labeled application rate of 1 lb. a.i./acre for grapes, 2.5 lb. a.i./acre for citrus peaches and nectarines, and 3.25 lb. a.i./acre for apples. The adjusted DFR values at reentry were 0.006 µg/cm² for gapes, 0.014 µg/cm² for peaches, nectarines, and citrus, and 0.15 µg/cm² for apples.

WORKER EXPOSURE

Ground Application

A mevinphos mixer/loader/applicator exposure study monitored daily (24-hr) DMP urinary excretion of 45 workers for six days during the peak use season in 1992 in Salinas, California (Krieger *et* al., 1993). This study was determined scientifically flawed and inappropriate for exposure assessment of mevinphos (Whalan, 1993; O'Malley, 1993; Fukuto, 1993; Oshima, 1993, Sanborn, 1993). There is no other mevinphos ground handler exposure studies available. Surrogate data are used as an alternative to estimate ground mixer/loader/applicators exposure to mevinphos. Because of the critical factors that must be considered in use of appropriate surrogate data, the choices are very limited. A study that monitored the exposure of workers to

oxydemeton-methyl was selected as the appropriate surrogate data to estimate ground handlers' dermal exposure to mevinphos, considering the following factors:

1. Data availability.
2. Both chemicals are liquid at room temperature.
3. Both chemicals are water and organic solvent soluble.
4. Both chemicals have a boiling point of 100 to 106 ^{o}C.
5. Identical end-use formulations.
6. Identical rates of application.
7. Identical crop uses.
8. Identical application method and equipment.
9. Identical use restrictions (closed system mixing/loading).
10. Comparable personal protective equipment requirements.

In this study, an emulsifiable concentrate formulation of oxydemeton-methyl was applied at a rate of 0.5 to 0.75 lb. a.i./acre to cabbage, broccoli, cauliflower, and Brussels sprouts, using either boom-type ground sprayers or airplanes (Oshita et al., 1988). A total of eleven workers were monitored during 24 applications. Each worker wore a shirt, long pants, socks, and cloth coveralls. Chemical resistant gloves, boots, rainsuit or standard Tyvek coveralls, hat, respirator, and a face shield or goggles were worn consistent with the use permit conditions. The mixing/loading operation was a closed system. Dosimeters were placed at several locations both under the cloth coveralls (protected) and outside of the rainsuits (unprotected). Hand exposure was measured using hand washes and knit nylon gloves worn under chemical resistant gloves. Chemical resistant gloves were worn only during mixing/loading and repair but not during application. Portable personal air sampling pumps were worn by the workers to sample air concentration. There were four applications using an enclosed cab, 17 applications using open cab spray rigs, and three applications by airplane. Dermal exposure was estimated based on residues found on protected dosimeters. Dosimeters with no detectable residues were assumed at 1/2 the minimum detectable level (MDL = 0.2 µg/sample). Body surface area and body weight as described in the exposure assessment guideline (Thongsinthusak et al., 1993) were used to calculate dermal exposure. Detectable levels of oxydemeton-methyl were found in the air samples only during six of the 24 exposure periods but at very low levels (0.76 µg/m^3 to 4.8 µg/m^3).

Because of the relatively high vapor pressure of mevinphos, inhalation exposure from the oxydemeton-methyl study is not an appropriate surrogate to estimate workers inhalation exposure to mevinphos. As a conservative measure, it was assumed that a ground mixer/loader/applicator (closed system mixing/loading and closed-cab application without respirator or open-cab application with respirator) will have the same level of inhalation exposure as a mevinphos mixer/loader of aerial application (see Table 5).

Dermal and inhalation exposure of mixer/loader/applicators using open-cab or closed-cab application equipment is shown in Table 4.

Table 4

Estimating Ground Mixer/Loader/Applicator
Exposure to Mevinphos Based on Surrogate Data

Work Task	Application Equipment	Dermal exposure µg/person/day	Inhalation exposure µg/person/day	ADD* µg/kg/day
M/L/A (n=17)	Open-cab	984 (±2.20)**	40.0	3.8
M/L/A (n=4)	Closed-cab	805 (±1.90)**	40.0	3.2

* Dermal absorption of 16.8 percent, body weight of 75.9 kg, eight-hour workday, 50 percent inhalation uptake, adjusted for 1 lb. a.i./acre.
**Geometric mean and standard deviation (log-normally distributed).

Personal protective equipment consisting of long-sleeved shirt, long-legged pants, Tyvek coveralls or rainsuit, chemical resistant gloves (during mixing/loading only), boots, hat, respirator (during open-cab application), and face shield or goggles.

Formoli WH&S, 1993

The use of mevinphos by airblast application equipment is not prohibited on the product label. However, it is not customary in California to use mevinphos by airblast. Application of mevinphos by such equipment in the past had been observed to associate with illness to workers (Ibarra, 1992).

Aerial Application

The estimates of exposure of mixer/loaders, pilots, and flaggers during aerial applications of mevinphos were obtained from studies conducted in Monterey and Imperial counties in 1991 (Maddy *et al*., 1981 and 1982).

For the study in Monterey County, an experienced crew of one major aerial pest control operator firm participated in a 3-day monitoring program. This firm had an excellent record of compliance with established safe use regulations and work practices. A closed system was used in mixing and loading mevinphos and transferring the resulting application mixture to the helicopter. The system had a manually operated probe to transfer the pesticide from the concentrate containers into the mix tank. A pump was used to load the application mixture to a helicopter, which took place every five to seven minutes.

The mixer/loaders wore shirts and pants under clean long-sleeved and long-legged coveralls, heavy rubber gloves, and rubber boots. Respirators were worn by all workers with the exception of the pilot on day two. Dermal and inhalation exposures were monitored. Patches were constructed of an outer layer of seven-ounce 65 percent Dacron polyester, 35 percent cotton twill and an inner layer of 100 percent cotton gauze backed by aluminum foil. Each patch had an exposed area of 49 cm^2. Patches were placed on the back of the neck, on each upper arm, on

each thigh, and on each side of the chest. Cotton gauze and outer cloth patches were analyzed separately. Pre- and postexposure hand rinses were performed using 250 mL distilled water. Inhalation exposure monitoring was accomplished by using a MSA Model S portable air pump drawing air at a rate of 1 liter per minute from the worker's breathing zone. The monitoring period ranged from 1.13 to 2.80 hours. Worker exposure estimates (Table 5) were extrapolated from exposures during these monitoring periods to a seven-hour workday. A seven-hour workday was used under the assumption that workers had to travel and prepare equipment and chemicals prior to and during the operation. This exposure time was also used by the referenced studies (Maddy, 1981 and 1982).

Dermal exposures were estimated from residues found in gauze pads. Half of the MDL (MDL = 0.005 µg/cm²) was used when the residue in the gauze pad indicated "ND". A clothing protection factor of 90 percent was assumed when cloth pad residue also indicated "ND" (Reinert *et al.,* 1986). Thigh and leg dermal exposures were extrapolated from the mean residues in gauze pads attached to thighs. Body surface areas, inhalation rate, and male body weight reported in the exposure assessment guidelines (Thongsinthusak *et al.,* 1993) were used in the estimation of exposure. Exposure estimates in Table 5 reflect the requirements of engineering controls and protective clothing by the current regulations and product labels. Enclosed cab or cockpit was assumed to provide 90 percent protection for dermal and inhalation exposure (Thongsinthusak *et al.,* 1991). Chemical resistant aprons worn by the mixers/loaders are assumed to provide 50 percent protection of the body exposure (exclude head, face, neck and hands). Goggles or face shields provide approximately 25 percent protection to the head, face, and neck (H F, N).

The second study was conducted in Imperial County and utilized fixed-wing airplanes where reloading of the airplanes took place every 30-40 minutes. Monitoring of worker exposure was done during routine commercial applications. One aerial pest control operator firm was monitored for a period of four days. Monitoring methods were similar to that used in the first study. The duration of monitoring ranged from 0.97 to 2.18 hours. Results in Table 5 for fixed-wing airplanes also represent the engineering controls and protective clothing as required by current regulations and the product labels. The seven-hour exposure estimates (Table 5) for a typical workday were extrapolated from exposures during these monitoring periods.

Table 5

Exposure of Mixers/loaders, Flaggers
and Pilots to Mevinphos During Aerial Application[a]

Work Task	Exposure (µg/7-hr day) Dermal H.F.N.	Body	Hands	Total	Inhalation	ADD[b] (ug/kg/day)
Helicopters						
Mixer/loader[c] (n=3)	287	334	325	1006+5.4	18+1.4	2.4+5.0
Pilot[d] (n=3)	80	42	80	207+1.6	8+1.6	0.5+1.6
Fixed-wing airplanes						
Mixer/loader[c] (n=4)	18	18	424	584+2.3	35+2.1	1.6+2.2
pilot[d] (n=4)	27	24	10	65+4.0	43+1.8	0.5+2.2
Flagger[e] (n=7)	3	4	2	11+13.0	1+13.8	0.04+11.3

a Geometric mean ± standard deviation. Total dermal exposure was calculated from total exposure of each worker, e. i. H.F.N. + Body + Hands. Body exposure excludes head (H), face (F), neck (N), and hand exposure.

b The dermal absorption is 16.8 percent. Body weight is 75.9 kg. Inhalation uptake and inhalation absorption are 50 percent (Raabe, 1988) and 100 percent, respectively.

c M/Ls: Engineering controls and clothing requirements - closed mixing and loading system, long-sleeved shirt, long-legged pants, chemical resistant gloves, chemical resistant apron, shoes and socks. Goggles or face shield must be worn when the system is under pressure.

d Pilot: Engineering controls and clothing requirements - enclosed cockpit, long-sleeved shirts, long-legged pants, shoes and socks.

e Flaggers: Engineering controls and clothing requirements - totally enclosed vehicle, long-sleeved shirts, long-legged pants, shoes and socks.

Thongsinthusak, WH&S, 1993

Applications Using Hand-Held Equipment

A mevinphos exposure study of greenhouse workers was conducted in Finland in 1990 (Jauhiainen *et al.,* 1992). Applicators used high pressure or knapsack sprayers to apply mevinphos to ornamentals. Significant decreases from the baselines were observed in RBC and plasma cholinesterase activities of applicators. Urinary DMP peaked 18 hours after the application and dropped below the detection limit of 0.02 µg/mL two days after the application. Urinary DMP 18 hours after the application was measured at 0.11 µg/mL for the applicator with 26% and 29% reduction in RBC and plasma cholinesterase activities, respectively. Mevinphos is no longer registered in California for use in the greenhouse.

Field Worker Exposure

The reentry interval for vegetable crops is 48 hours. However, harvesting is not permitted until the preharvest interval (PHI) has expired. The PHI varies with crop and the rate of application.

A study of lettuce harvesters' exposure to folpet estimated dermal transfer factors of 710 cm²/hour and 364 cm²/hour during cutting and packing of lettuce, respectively (Blewett *et al.*, 1989). A transfer factor of 710 cm²/hour was used to estimate vegetable crop harvesters' exposure to mevinphos. Exposure was calculated by multiplying the DFR values at the expiration of PHI for each crop by the transfer factor (710 cm²/hour).

The PHIs for mevinphos treated fruit trees in California are analogous to their respective reentry intervals. The PHI for grapes is five days but the reentry interval for other work activities is four days. Dermal transfer factors of 3,250 cm²/hr, 3,635 cm²/hr, and 9,500 cm²/hr were calculated for grape suckering/pulling leaves, girdling, and cane turning, respectively (Haskell, 1992). These transfer factors were based on propargite, methomyl, and captan worker exposure studies during these work activities in grapes. Dermal transfer factors of 4,180 cm²/hr and 3,315 cm²/hr were calculated for harvesting and thinning fruit trees (Formoli and Fong, 1993). The transfer factor for harvesters and thinners were calculated based on azinphos-methyl worker exposure studies during these work activities in apples, peaches, and nectarines. The exposures to field workers of grapes and fruit trees were calculated using the DFR values estimated at DFR section of this document. The estimates of exposure shown in Table 6 are for an eight-hour workday.

Table 6

Estimate of Field Workers' Exposure to Mevinphos

Activity	Crop	PHI days	DFR µg/cm²	Transfer cm²/hr	ADD µg/kg/day
Harvesting	Lettuce (Head)	2	0.016	710	0.20
Harvesting	Lettuce (Leaf)	7	neg	710	neg
Harvesting	Cauliflower	3	0.111	710	1.40
Harvesting	Celery	3	0.011	710	0.14
Harvesting	Chinese Cabbage	2	0.122	710	1.53
Harvesting	Peaches, Nectarines, Citrus	4**	0.014	4,180	1.04
Thinning	Peaches, Nectarines, Citrus	4**	0.014	3,315	0.82
Harvesting	Apples	2**	0.150	4,180	11.10
Thinning	Apples	2**	0.150	3,315	8.81
Suckering	grapes	4**	0.006	3,250	0.35
Girdling	rapes	4**	0.006	3,635	0.39
Cane turning	grapes	4**	0.006	9,500	1.01

* Eight-hour workday, 75.9 kg body weight and 16.8% dermal absorption.
** Reentry interval
neg = negligible

Formoli, WH&S, 1992

Table 7

Estimated Mevinphos
Absorbed Daily Dosages for Different Work Activities

Task	Application Equipment	Crop	ADD µg/kg/day	AADD* µg/kg/day
Pilot	Aerial	Artichoke	0.5	0.03
M/L	Aerial	Vegetable	2.4	0.14
Flagger	Aerial	Artichoke	0.04	0.002
M/L/A	Ground	Vegetables	3.8	0.22
Harvesters		Vegetables	neg. - 1.5	neg. - 0.09
Field workers		Fruit trees	0.8-11.1	0.05-0.64
Field workers		Grapes	0.4-1.0	0.02-0.06

* 21 workdays a year (Haskell, 1993).

Clothing and Equipment:

M/L/As: Closed mixing and loading system, long-sleeved shirt, long-legged pants, Tyvek coveralls or rainsuits, chemical resistant gloves, chemical resistant shoes or boots, goggles or face shield, a hat, and a NIOSH/MSHA approved respirator.

M/Ls (aerial): Closed mixing and loading system, long-sleeved shirt, long-legged pants, chemical resistant gloves, chemical resistant apron, shoes and socks. Goggles or face shield when the system is under pressure.

Flaggers: Totally enclosed vehicle, long-sleeved shirts, long-legged pants, shoes and socks.

Pilots: Cockpit, long-sleeved shirts, long-legged pants, shoes and socks.

Vegetable harvesters: Long- or short-sleeved shirt, long-legged pants, gloves and shoes.

Grape and fruit tree field workers: Long-sleeved shirt, long-legged pants, and shoes.

neg - negligible

Formoli, WH&S, 1993

REFERENCES

Blewett, T.C., S.G. Saiz, M.J. Feletto, R.I. Krieger, S. Margetich, K. Zumwalt and R. Tootle. 1989. Lettuce harvester exposure to folpet in Salinas Valley. Worker Health and Safety Branch, California Department of Food and Agriculture, Sacramento, CA. HS-1442.

Casida, J.E., P.E. Gatterdam, J.B. Knaak, R.D. Lance and R.P Niedermeier. 1958. Bovine metabolism of organophosphate insecticides. Subacute feeding studies with O,O-dimethyl 1-carbo-methoxy-l-propan-2-yl phosphate. J. Agr. Fd. Chem. 6:658, cited in DPR Registration Doc. No. 157-006.

Formoli, T.A. and H.R. Fong. 1993. Estimation of exposure of persons in California to pesticide products that contain azinphos-methyl. Worker Health and Safety Branch, Department of Pesticide Regulation, Sacramento, CA. HS-1650.

Fukuto, T.R. 1993. Analysis of the reports on determination of mevinphos exposure of handlers (TAS) and disposition and metabolism of ^{14}C-labeled mevinphos in rats (MRI). Letter dated November 15. University of California, Riverside.

Gilbert R.O. 1987. *Statistical Methods for Environmental Pollution Monitoring,* Chap. 16. New York: Van Nostrand Reinhold Company.

Haskell, D. 1992. Estimation of exposure of persons in California to pesticide products that contain mancozeb (draft). Worker Health and Safety Branch, Department of Pesticide Regulation, Sacramento, CA. HS-1525.

Haskell, D. 1993. Occupational exposure to mevinphos from use on vegetable row crops. Memorandum. Worker Health and Safety Branch, Department of Pesticide Regulation, Sacramento, CA.

Ibarra, M. February 5, 1992. Telephone conversation, Pesticide Enforcement Branch, Department of Pesticide Regulation, Fresno, CA.

Jauhiainen, A., J. Kangas, S. Laitinen and K. Savolainen. 1992. Biological monitoring of worker exposed to mevinphos in greenhouses. Bull. Environ. Contain. Toxicol. 49:37-43.

Jeffcoat, R. 1993. Dermal absorption of mevinphos in rats at three dose levels (preliminary summary report). Research Triangle Institute study number 64C-5494, AMVAC Chemical Corporation. DPR Registration Doc. No. 157-060.

Krieger, R.I., E. Patel, and D. Sturgill. 1993. Determination of mevinphos exposures of handlers. Technical Assessment Systems, Inc. Washington, D.C.

Maddy, K.T., S. Edmiston and D. Alcoser. 1985. Dissipation of mevinphos following application to head lettuce, leaf lettuce, cauliflower and Chinese cabbage. Worker Health and Safety Branch, California Department of Food and Agriculture, Sacramento, CA. HS- 1269.

Maddy, K. T., C. Winter, S. Cepello and A.S Fredrickson. 1981. Monitoring of potential occupational exposure of mixers/loaders and pilots during application of Phosdrin (mevinphos) in Monterey County in 1981. Worker Health and Safety Branch, California Department of Food and Agriculture. HS-876.

Maddy, K. T., C. Winter, S. Cepello and A.S Fredrickson. 1982. Monitoring of potential occupational exposure of mixers/loaders, pilots, and flaggers during application of Phosdrin (mevinphos) in Imperial County in 1981. Worker Health and Safety Branch, California Department of Food and Agriculture. HS-889.

O'Malley, M. 1992. Systemic illnesses associated with exposure to mevinphos in California, 1982-1989. Worker Health and Safety Branch, Department of Pesticide Regulation, Sacramento, CA. HS-1626.

O'Malley, M. 1993. HS-1681: Mevinphos risk mitigation proposal for human exposure reduction. Memorandum dated August 6. Worker Health and Safety Branch. Department of Pesticide Regulation.

Oshima, R.J. 1993. Scientific dispute resolution for mevinphos. Memorandum dated November 30. Division of Registration and, Health Evaluation, Department of Pesticide Regulation.

Oshita C.M., F.A. Schneider, and S. Margetich. 1988. An exposure study of mixer/loaders and applicators using oxydemeton-methyl (Metasystox-R) in the Salinas and Santa Maria Valleys of California in 1986. Worker Health and Safety Branch, California Department of Food and Agriculture, Sacramento, CA. HS-1398.

Pesticide Use Report (PUR) Annual 1990, indexed by chemical. 1992. Department of Pesticide Regulation, Sacramento, CA.

Raabe, O.G. 1988. Inhalation uptake of xenobiotic vapors by people. Contract number CARB A 5-155 (March 1988). University of California, Davis, California.

Reddy, V.T., T. Freeman, L. Litle, and M. Cannon. 1991. Disposition and metabolism of ^{14}C-labeled mevinphos in rats. MRI Project No. 9485-B. Midwest Research Institute, Kansas City, Missouri. DPR Registration Document No. 157-043.

Reinert, J. C., A.P. Nielsen, J.E. Davis, D.K. Hickey, H.N. Nigg, G.W. Ware, C. Lunchick, O. Hernandez, F.L. Smith, and D.M. Mazzetta. 1986. Sudivision U: Applicator Exposure Monitoring. U. S. Environmental Protection Agency, Washington, D.C.

Sanborn, J. 1993. Review of Roy Fukuto's letter on mevinphos study conducted by TAS. Review Memorandum dated December 1. Worker Health and Safety Branch, Department of Pesticide Regulation.

Spencer, J.R., B. Hernandez, F.A. Schneider, M. Gonzales, S. Beguin and R.I. Krieger. 1991. Seasonal Phosdrin degradation on row crops in Monterey County, 1990. Department of Pesticide Regulation, Sacramento, CA. HS-1608.

Thongsinthusak, T., B. Brodberg, J. Ross, R. Krieger and D. Gibbons. 1991. Developing pesticide exposure mitigation strategies for handlers and harvesters. Fourth Chemical Congress of North America and 202nd ACS National Meeting, New York (August 25-30, 1991). Poster No. 43.

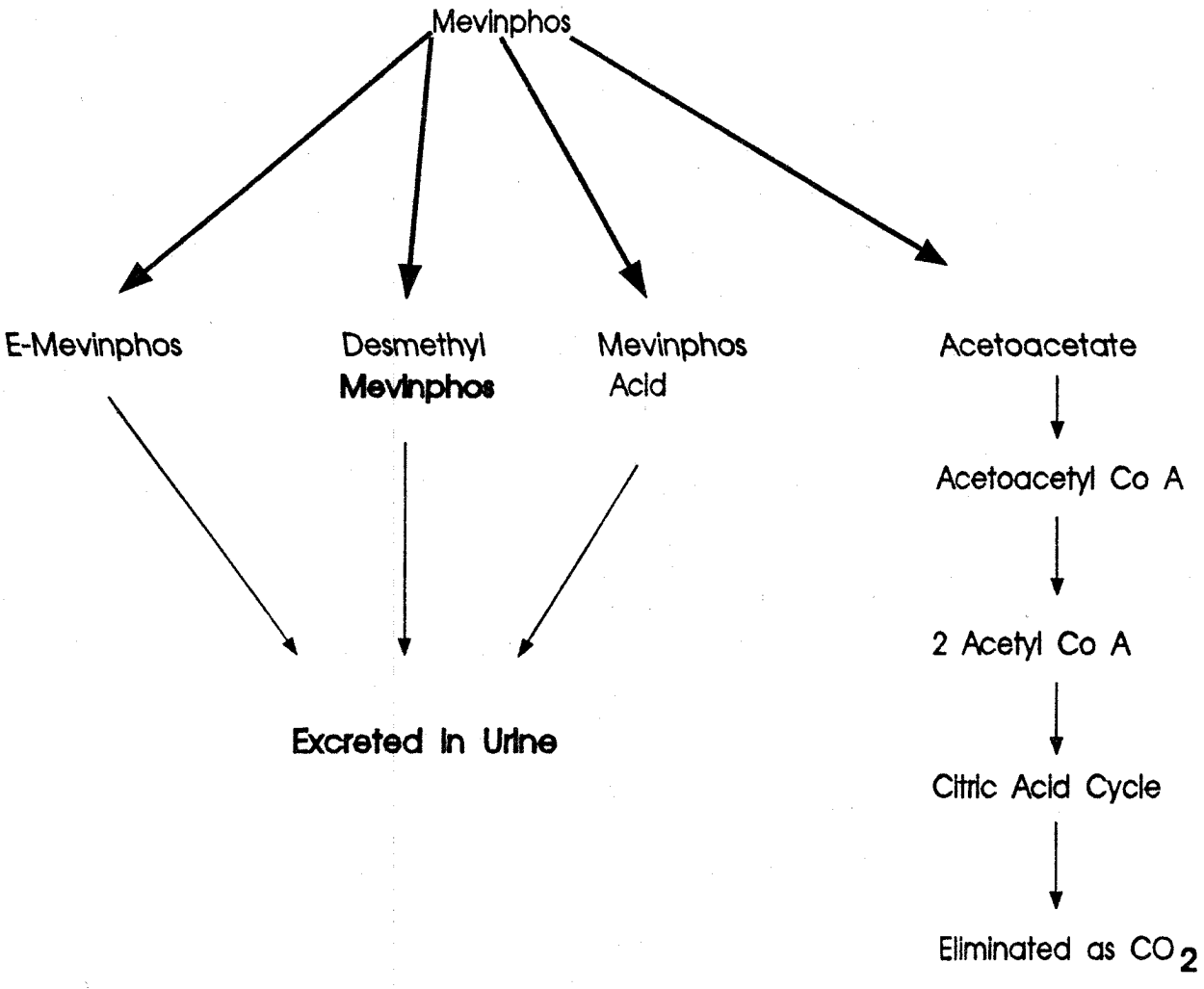
Thongsinthusak, T., J.H. Ross, and D. Meinders. 1993. Guidance for the preparation of human pesticide exposure assessment documents. Worker Health and Safety Branch, Department of Pesticide Regulation, Sacramento, CA. HS-1612.

Title 3, California Administrative Code (CAC). Division 6, Pesticides and pest control operations. Chapter 3, Pest control operations, Subchapter 3 (Extracts). Pesticide Worker Safety. Sacramento, CA. HS-036

Whalan, J.E. 1993. Mevinphos: FIFRA Sec. 6 (a)(2) submission of a human exposure study. Memorandum dated July 26. Toxicology Branch I, Health Effects Division (H7509C), Office of Prevention, Pesticides and Toxic Substances, U.S. EPA, Washington, D.C.

Figure 2

Possible Metabolic Pathway of Mevinphos in Sprague-Dawley Rats*



* Adopted from Reddy, 1991.